EXPLORING THE PHYSICAL PROPERTIES OF HIGH FIDELITY PHOBOS REGOLITH SIMULANTS.

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Introduction: JAXA is developing a major mission with the goal of returning a sample from the Martian moon Phobos. The design of the Martian Moons eXploration (MMX) mission is challenging in part because of the unknowns about the mineralogy and the origin of Phobos and Deimos. There are two leading theories for the formation of the Martian moons. (1) That the moons formed from a debris disk composed of ejecta from a major impact on Mars. In this scenario Phobos and Deimos would be composed of a mixture of impactor and target material. Because of the low albedo and relatively featureless reflectance spectra of the moons, the suggestion is that that the impactor was a low-albedo primitive asteroid and this material is mixed with mars crustal material to form the moons. (2) The other theory is that the moons formed from a debris disk of primitive asteroid material that broke up within the Martian Hill Sphere. In this case the moons would be largely composed of primitive asteroid material.

MMX will be interacting directly with the surface regolith of Phobos. For the design, testing and validation of the spacecraft hardware and mission operations concepts, high fidelity simulants for the possible range of Phobos mineralogies can be an important part of mission development. Our group has been developing high-fidelity, mineralogy based simulants using the latest mineralogical data from asteroids and Martian surface missions. The advantage of this mineralogy-based approach is that it captures the inherent physical properties and grain-grain interactions of the constituent minerals. The development efforts are reported in [1]. Here we describe our program of physical and mechanical properties measurements with the goal of supporting the MMX mission and characterizing the physical properties of the possible Phobos regolith mineralogies.

Physical Properties Testing: As described in [1] we are using two simulant mixtures to represent the different possible origins of Phobos: Phobos Captured Asteroid (PCA-1) based on CI chondrites [2], and Phobos Giant Impact (PGI-1) containing a mix of 57% CI carbonaceous chondrite simulant material and 43% Martian mantle material (primarily olivine and pyroxene). Our group is current performing a range of physical properties measurements on these materials.

The physical properties measurements our group is conducting include: compressive strength, tensile and shear strength, electrostatics properties, magnetic properties, grain hardness, abrasivity, surface friction, angle of repose, internal friction, powder cohesion, adhesion, compressibility of regolith, compactibility of regolith, heat capacity, thermal conductivity, thermal diffusivity, thermal expansion, thermal cracking behavior, and thermal cycling.

The advantage of our mineralogy-based approach to simulants is that it realistically captures the physical properties of the grain-to-grain interactions of the materials that make up exploration targets. Data from these measurements can be used to constrain design and functional requirements for a range of future hardware and missions.

References: [1] Cannon et al., (2017) *Proceedings of 2017 Lunar and Planetary Science Conference.* [2] Covey et al. (2016) *Proceedings of 2016 ASCE Earth and Space Conference*.